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(54) SOFT LANDING SYSTEM AND METHOD OF ACHIEVING SAME

(71) Applicant: **Velco Gray Inc.**, Houston, TX (US)

(72) Inventors: **Ronald Baker**, Spring, TX (US); **Pradeep Dhuper**, Spring, TX (US)

(73) Assignee: **Vetco Gray Inc.**, Houston, TX (US)

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(51) **Int. Cl.**

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E21B 41/00	(2006.01)
E21B 41/10	(2006.01)
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(52) **U.S. Cl.**

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(58) **Field of Classification Search**

CPC E21B 33/038

See application file for complete search history.

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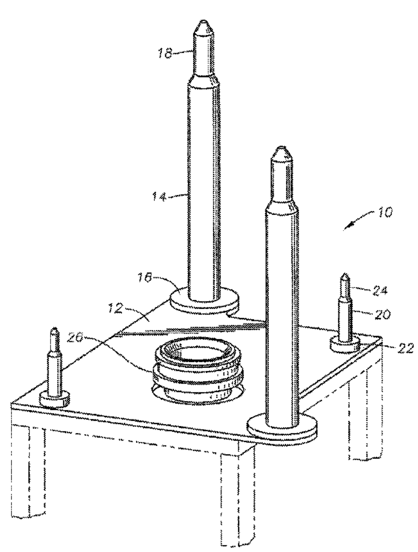
Primary Examiner — Matthew R Buck
Assistant Examiner — Aaron Lembo
(74) *Attorney, Agent, or Firm* — Bracewell LLP

(57) **ABSTRACT**

A subsea wireline system for soft landing equipment during installation. The subsea soft landing wireline system includes coarse alignment members that can be part of a tree and interact with a funnel located on the equipment to be installed by the soft landing system. Smaller alignment members can provide fine alignment and also interact with a funnel located on the equipment to be installed. The funnels are used to trap sea water that provides a cushion for the equipment being installed. Once in alignment, trapped water can be released from the funnel via a restricted orifice or a control valve located on an ROV. The system achieves soft landing without the use of a running tool, thus reducing expense.

20 Claims, 7 Drawing Sheets



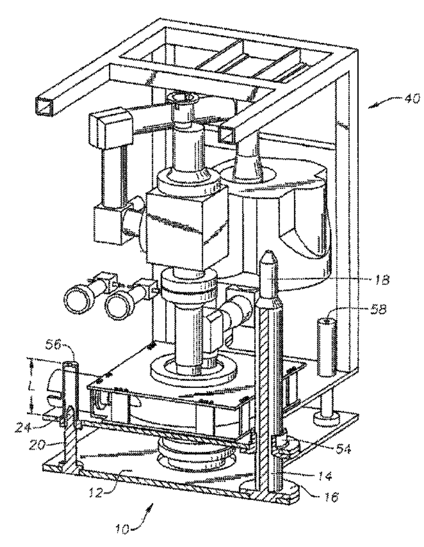


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Fig. 1

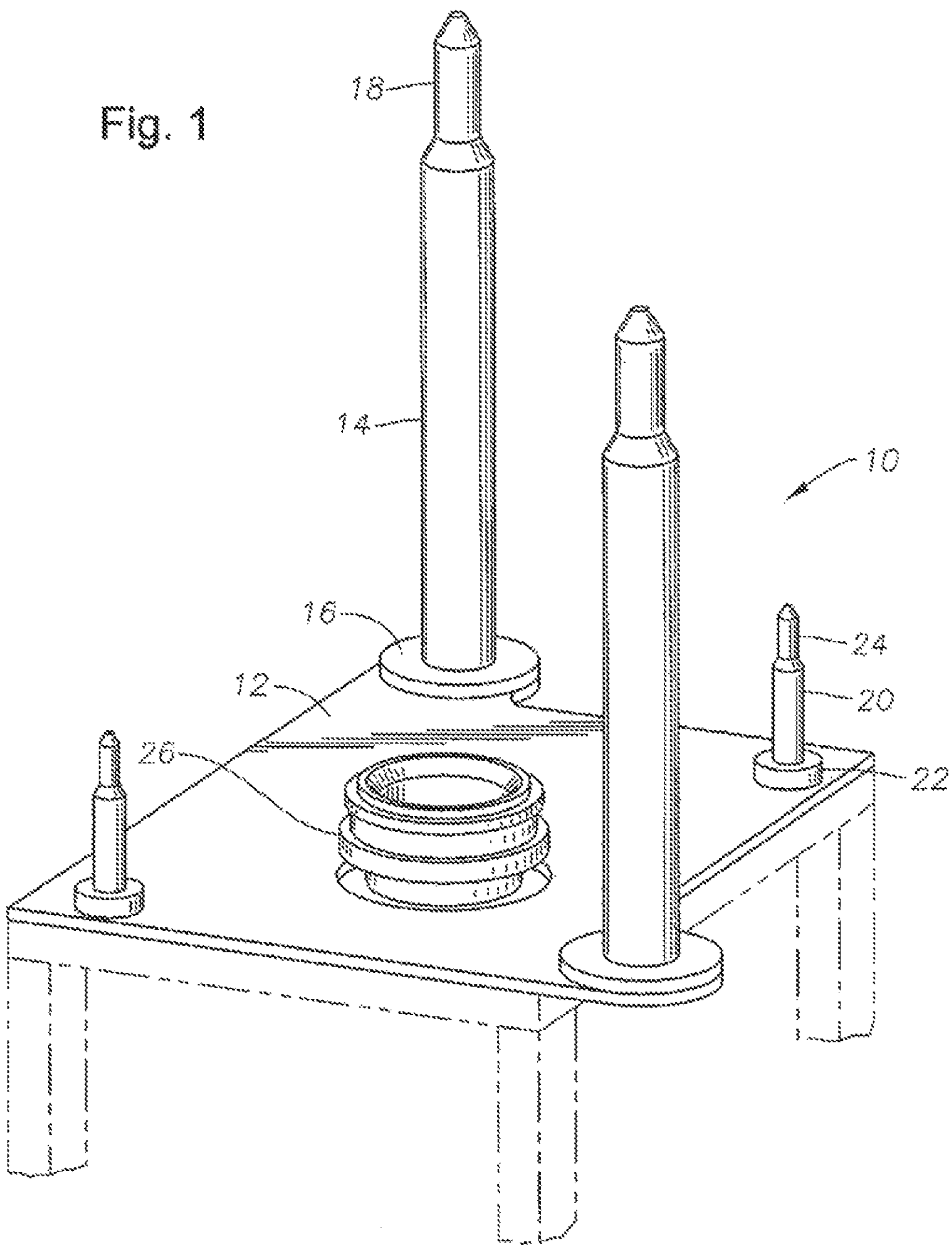


Fig. 2

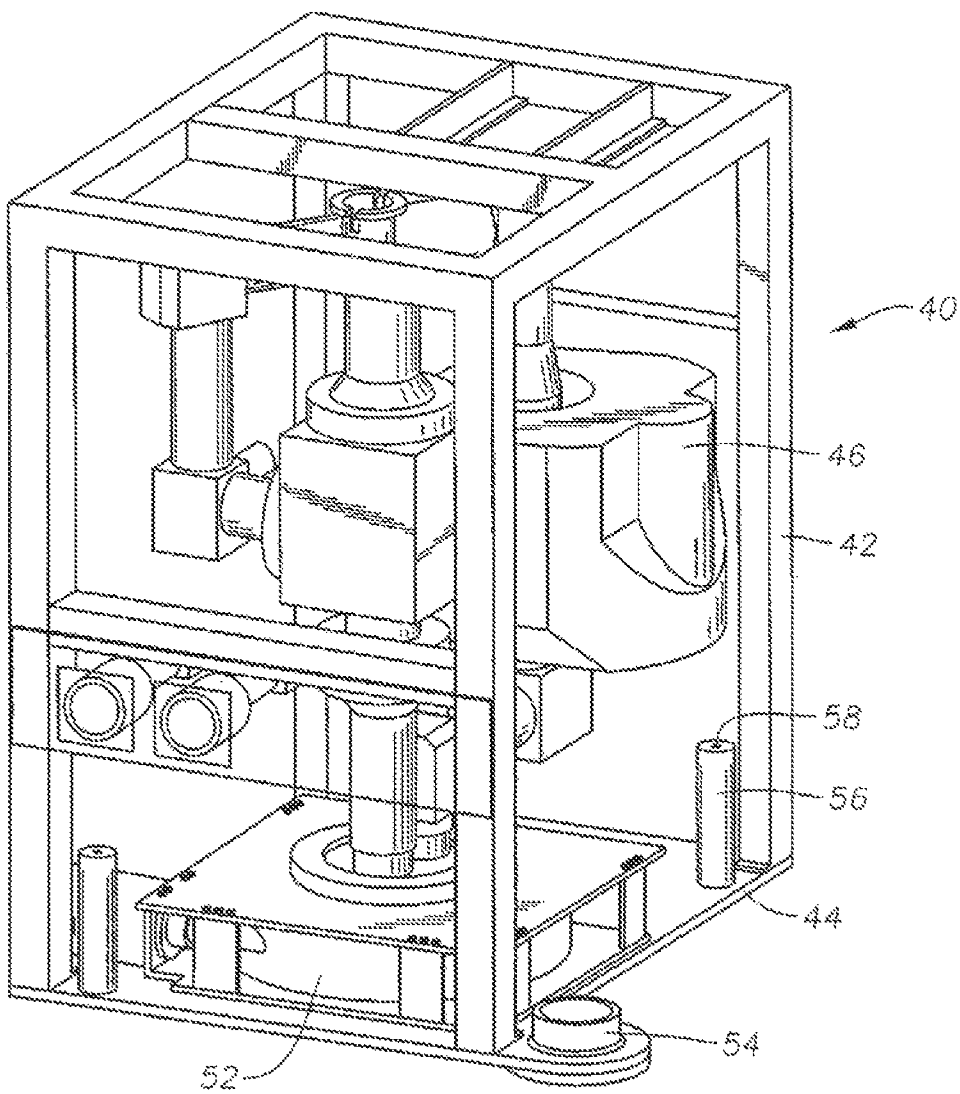


Fig. 3

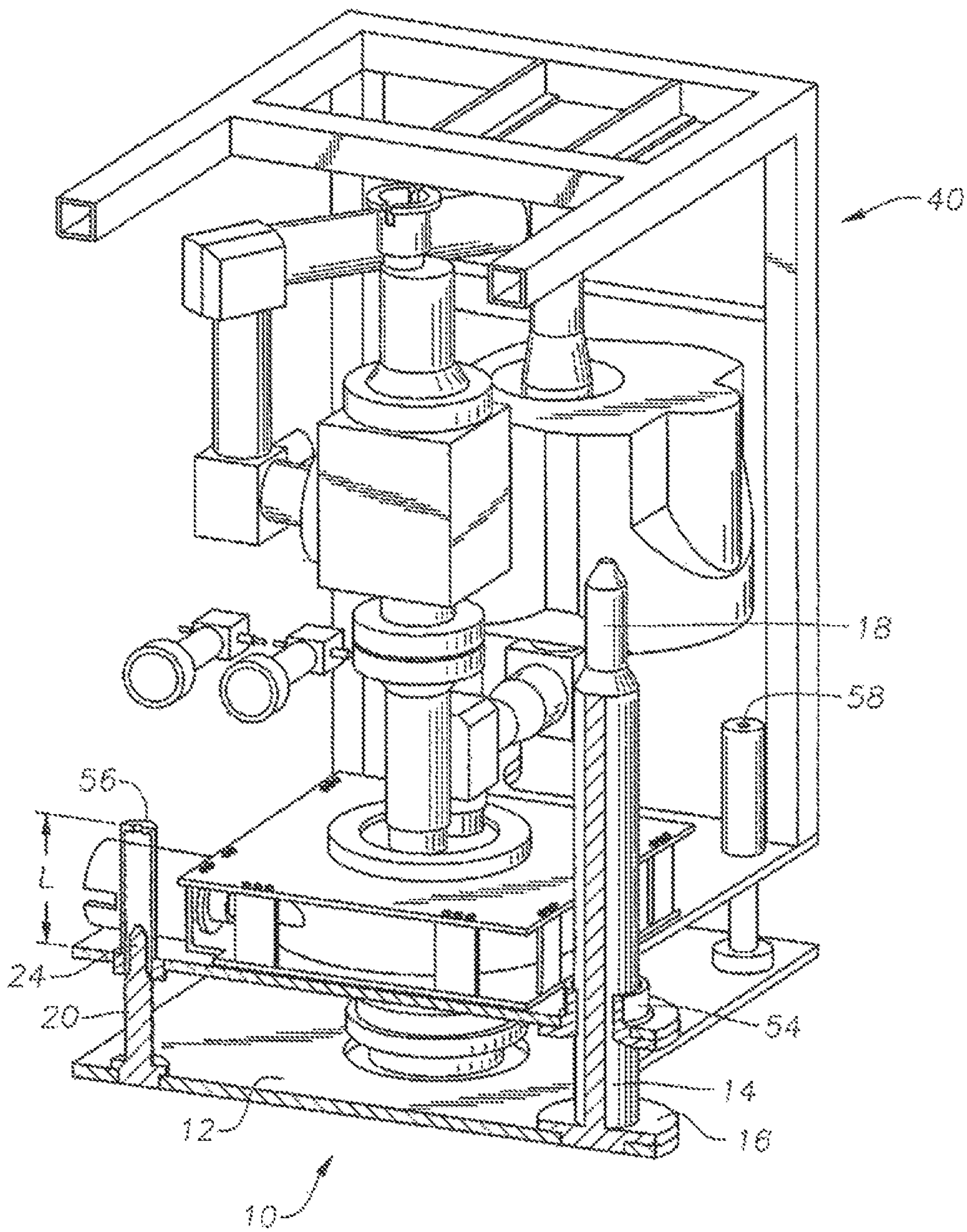


Fig. 3A

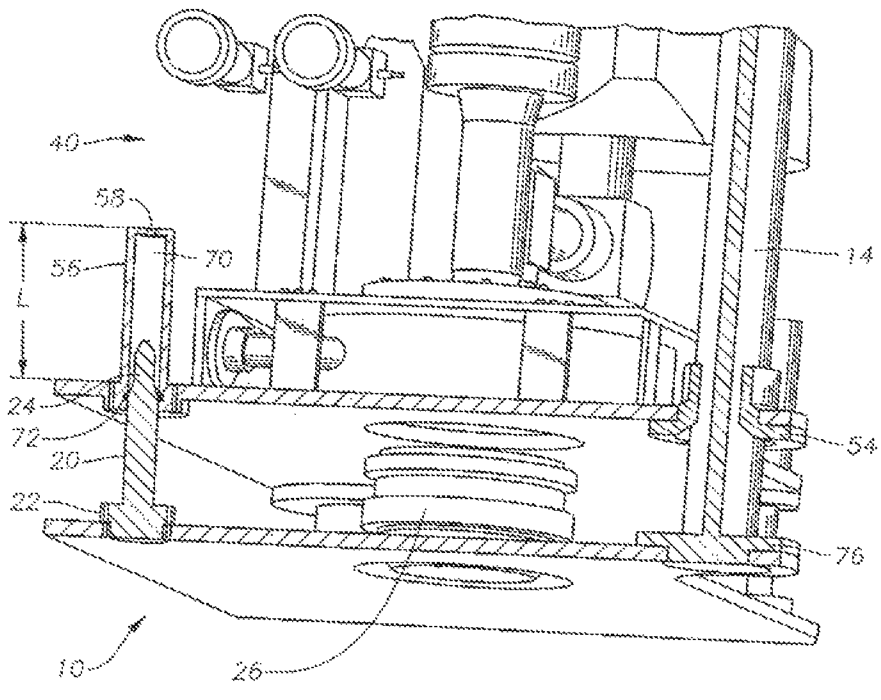


Fig. 4

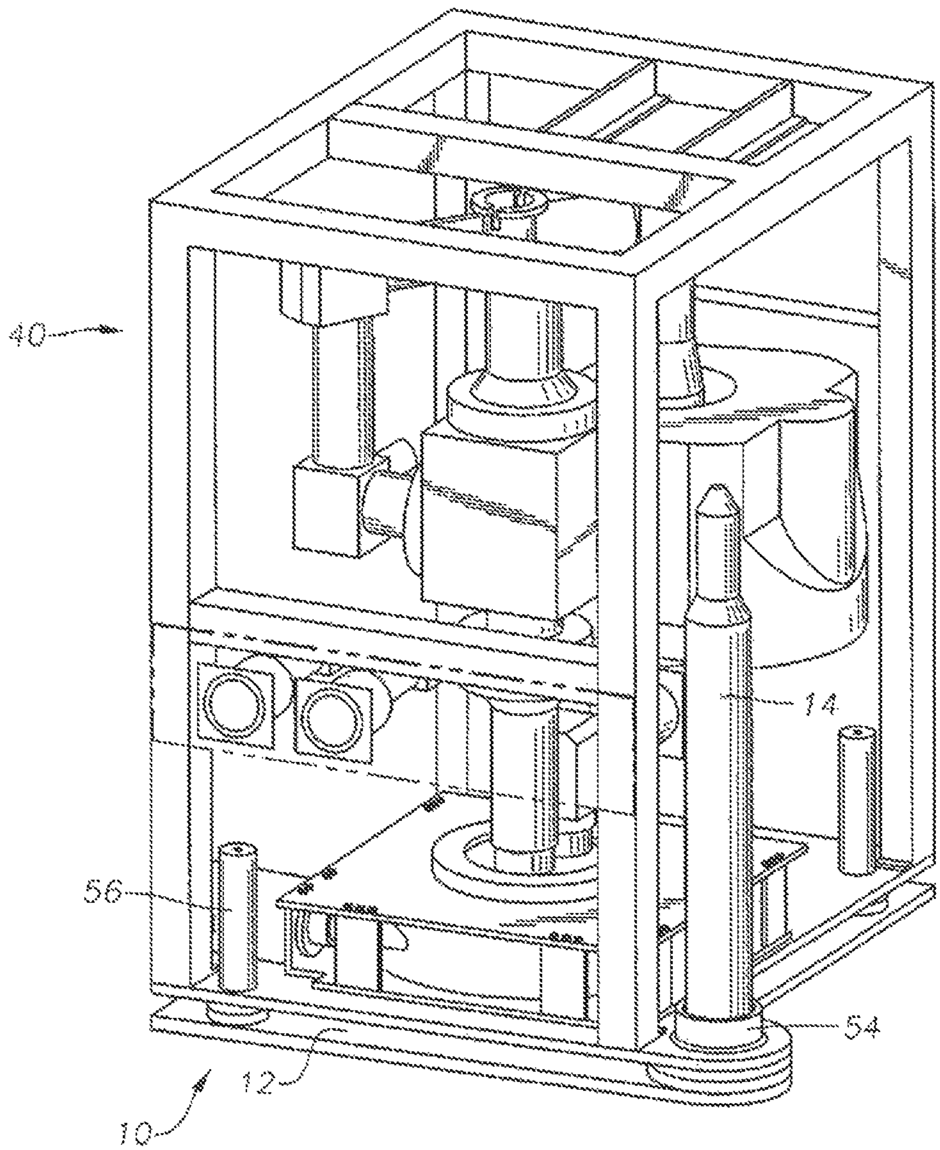


Fig. 5

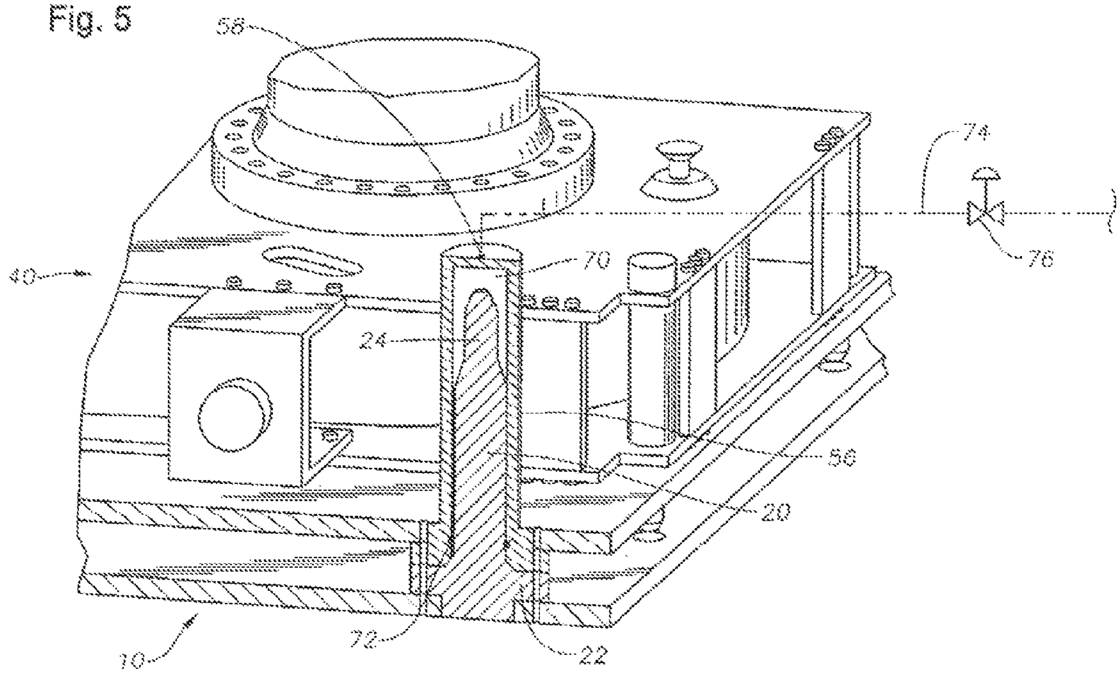
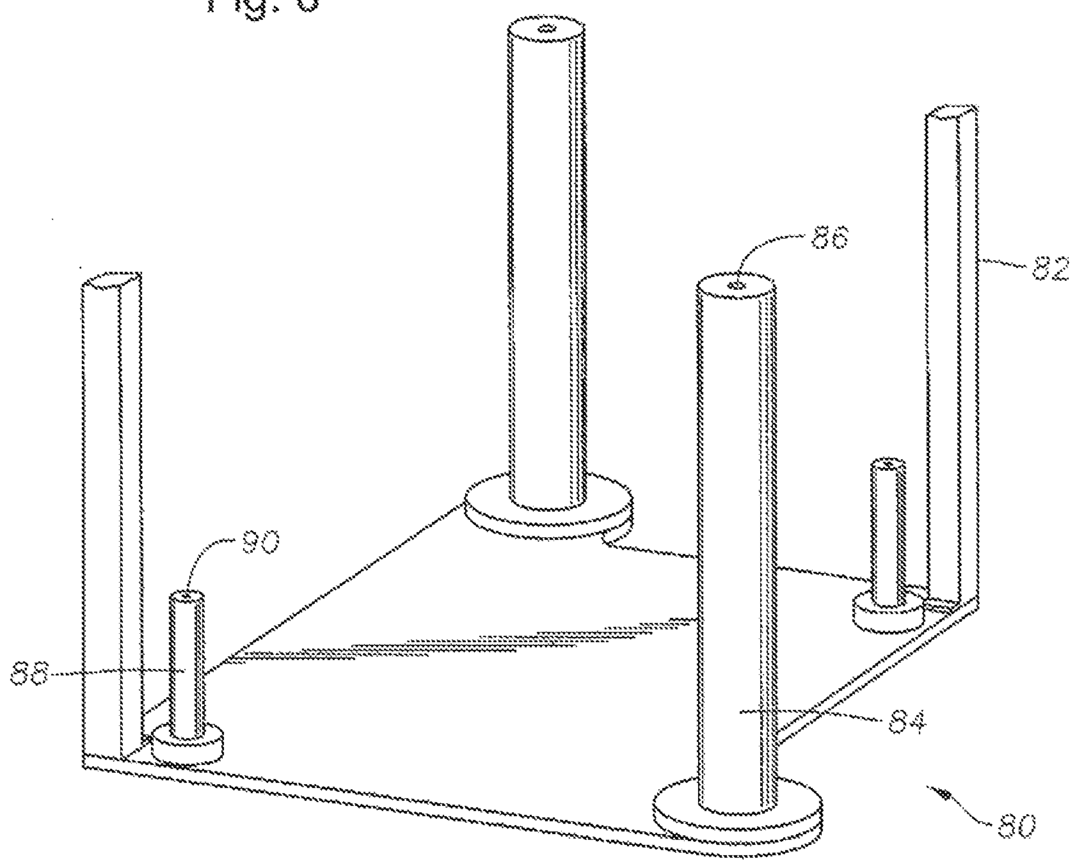


Fig. 6



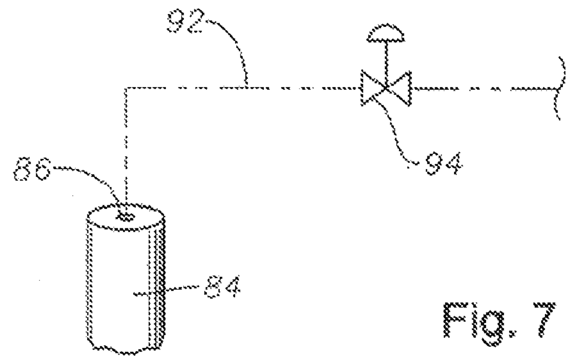


Fig. 7

SOFT LANDING SYSTEM AND METHOD OF ACHIEVING SAME

CROSS REFERENCE TO RELATED APPLICATION

This application is a continuation of Ser. No. 13/277,395, filed Oct. 20, 2011.

FIELD OF THE INVENTION

This invention relates in general to subsea wireline installed equipment, and in particular, a method of achieving a soft landing with subsea wireline installed equipment, without using a running tool.

BACKGROUND OF THE INVENTION

Typically, subsea equipment used in oil and gas applications must be lowered to a wellhead, a subsea equipment or system, such as a Christmas tree, or other site at the seabed. One type of subsea equipment that is lowered into the sea for installation may be a flow control module, for example. A flow control module is typically a preassembled package that may include a flow control valve and a production fluid connection that can mate with a hub on a subsea equipment or system, such as a Christmas tree. The hub on the Christmas tree may include a production fluid conduit to allow for the flow of production fluid from the well. The Christmas tree is typically mounted to a wellhead.

Typically, the flow control module may also include electrical and hydraulic connections as well as gaskets. The electrical and hydraulic connections may be used to control and serve components on the tree, such as valves. These connections or gaskets may be assembled on a flange of the production fluid connection for mating with corresponding connections on the tree hub. A stab and funnel system between the tree and flow package is typically used to align the production conduit and the several connections on the flow control package with those on the tree hub. Hard landing the flow control package on the tree may damage the connections at the hub, given the heavy weight of many equipment packages. To reduce the possibility of damage to the connections, the flow control module can be soft landed onto the tree. Soft landing is carried out by a running tool having a complex system of hydraulic cylinders and valves that slow the descent of the flow module package as it is landed onto the tree. However, the use of such soft landing running tools can be very expensive.

A need exists for a technique to achieve soft landing of subsea equipment without the use of a running tool.

SUMMARY OF THE INVENTION

In an embodiment of the invention, a soft landing wireline system utilized to install subsea equipment includes coarse alignment members or stabs and corresponding coarse alignment funnels, rings, or receptacles for guiding the coarse alignment members. Soft landing feature may be used on various types of subsea equipment or systems, including but not limited to manifolds, pipeline end manifolds (PLEMs), and pipeline end terminations (PLETs). Further, the soft landing wireline system could also be used in the installation of valves, actuators, chokes, and other components. The coarse alignment members may be part of a subsea equipment or system mounted on a wellhead and may interact with a funnel located on the equipment to be landed, such as a flow control module, to be installed by the soft landing subsea wireline system. The coarse alignment members and funnels provide general alignment of the equipment to be installed, preventing rotation of the equipment once at the subsea equipment or system. The subsea equipment or system.

In this embodiment, fine alignment members or stabs that are shorter and smaller in diameter than the coarse alignment members, provide fine alignment of the lowered equipment. Similar to the coarse alignment member, the line alignment members may be part of the subsea equipment or system mounted to the wellhead. The fine alignment members may also interact with fine alignment funnels or receptacles, that are located on the equipment to be installed. The fine alignment provides additional guiding of the equipment to facilitate mating of connections between the equipment and the subsea equipment or system.

Either or both of the coarse and fine alignment funnels may be used to trap sea water that can provide a cushion or resistance for the equipment being installed. The alignment members together with the alignment funnels create a type of piston and cylinder arrangement with the trapped water acting as the cushion. The size of the funnels may vary depending on the weight of the equipment and rate of descent. Larger equipment would require a larger cushion of sea water and thus a larger funnel. Once the equipment is in alignment, trapped water in the funnel can be released from the funnel via a restricted orifice or a control valve operated by a remotely operated vehicle (ROV). As the equipment settles and lands onto the subsea equipment such as a Christmas tree, the production fluid connection as well as electrical, hydraulic, and any other auxiliary connections or gaskets, mate with corresponding connections located at a hub of the subsea equipment. The possibility of damage to these connections or gaskets is advantageously minimized by the soft landing wireline system and achieves the soft landing of the subsea equipment without the use of a running tool, reducing associated expenses.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**, illustrates a perspective view of an embodiment of a portion of a subsea equipment or system, in accordance with the invention;

FIG. **2**, illustrates a perspective view of an embodiment of an equipment package for landing on subsea equipment of FIG. **1**, in accordance with the invention;

FIG. **3**, illustrates a perspective partial sectional view of an embodiment of equipment package landing on the subsea equipment, in accordance with the invention;

FIG. **3**A, illustrates a lower perspective view of an embodiment of equipment package landing on the subsea equipment, in accordance with the invention;

FIG. **4**, illustrates a perspective view of an embodiment of equipment package landed on the subsea equipment, in accordance with the invention;

FIG. **5**, illustrates a perspective partial sectional view of an embodiment of funnel and stab used in soft landing, in accordance with the invention;

FIG. **6**, illustrates a partial perspective view of an embodiment of an equipment package for landing on subsea equipment of FIG. **1**, in accordance with the invention;

FIG. **7**, illustrates a perspective partial sectional view of an embodiment of funnel and stab used in soft landing, in accordance with the invention.

DETAILED DESCRIPTION OF THE INVENTION

FIG. **1** shows a perspective view of an embodiment of a portion of a subsea equipment or system **10**, such as a Christmas tree, having a landing base or platform **12**, that may be installed at a wellhead located at a seabed. In this embodiment, coarse alignment members or stabs **14** may be part of the subsea equipment **10** and may be mounted to the subsea equipment via a base **16**. Coarse alignment members **14** may be used to provide general guidance or positioning for equipment being landed onto subsea equipment **10**. Bolts (not shown) may be used to secure base **16** of the coarse alignment members **14** to the subsea equipment **10**. A top end **18** of the coarse alignment member **14** may have a smaller diameter than the rest of the coarse alignment member. Top end **18** of the coarse alignment member **14** may have a conical shape. In this embodiment, the two coarse alignment members **14** are mounted on the subsea equipment **10** diagonally from each other. Diagonal mounting of coarse alignment members **14** helps prevent rotation of equipment being installed or landed on the subsea equipment **10**.

Continuing to refer to FIG. **1**, fine alignment members or stabs **20** may also be part of the subsea equipment **10** and may be mounted to the subsea equipment via a base **22**. The fine alignment members **20** are smaller in length and diameter than the coarse alignment members **14** and fine tune positioning of equipment being landed on subsea equipment **10**. The length of the coarse alignment members **14** will be longer than that of the fine alignment members **20** by a factor that can vary with the type of equipment package that is being landed and type of application. For example, the length of the coarse alignment member **14** may be from about 10 percent taller than the fine alignment member **20** to more than five times taller. Bolts (not shown) may be used to secure base **22** of the fine alignment members **20** to the subsea equipment **10**. A top end **24** of the coarse alignment member **20** may have a smaller diameter than the rest of the fine alignment member. Top end **24** of the coarse alignment member **14** may have a conical shape. In this embodiment, the two coarse alignment members **14** are mounted on the subsea equipment **10** diagonally from each other. Thus, the coarse alignment members **14** and fine alignment members **20** may be alternatingly mounted at each corner of the landing platform **12**. A hub **26** on the subsea equipment **10** is provided on the subsea equipment platform **12** for mating with equipment landed on the subsea equipment **10**. Equipment landing will be explained further below.

FIG. **2** shows a perspective view of an embodiment of a portion of an equipment package **40** having a frame **42** and a base **44**, that may be landed on the subsea equipment **10** (FIG. **1**). Equipment package **40** may be any type of subsea equipment or package lowered via wireline (not shown) to the previously installed subsea equipment **10**, such as a Christmas tree (FIG. **1**). For example, the equipment package **40** may be a flow control module that has a flow control device **46** that is in fluid communication with well once installed on subsea equipment **10** (FIG. **1**. In this embodiment, equipment package **40** may have a generally central fluid connection **52** on which portions of the flow control device **46** may be mounted. Further, the fluid connection **52** may have a lower portion for mating with hub **26** (FIG. **1**) located on the subsea equipment platform **12** (FIG. **1**).

Continuing to refer to FIG. **2**, a coarse alignment ring or receptacle **54** may be located at a corner of the base **44** of equipment package **40**. In this embodiment, a second coarse alignment ring **54**, obscured in view, may be located diagonally opposite from coarse alignment ring shown. Coarse alignment rings **54** interact with coarse alignment members **14** mounted on the subsea equipment **10** (FIG. **1**) to provide general alignment of the equipment package **40** to be landed on the subsea equipment, preventing rotation of the equipment package once coarse alignment members **14** (FIG. **1**) engage coarse alignment rings **54**. Clearances between coarse alignment members **14** and coarse alignment ring or receptacle **54** may be around one inch to facilitate mating.

Continuing to refer to FIG. **2**, a fine alignment funnel or receptacle **56** may be located at a corner of the base **44** of equipment package **40**. In this embodiment, a second fine alignment funnel **56** may be located such that the equipment package **40** is balanced and oriented in a desired manner. For example, in this embodiment the second fine alignment funnel **56** is diagonally opposite from the other fine alignment receptacle shown. Fine alignment funnel **56** interacts with fine alignment members **20** mounted on the subsea equipment **10** (FIG. **1**) to provide additional guiding of the equipment package **40** once coarse alignment is achieved and the equipment package continues moving downward towards landing platform **12** of subsea equipment **10** (FIG. **1**). Clearance between the fine alignment members **20** and fine alignment receptacle **56** is smaller than for coarse alignment to allow for more precise orientation. Fine alignment facilitates mating of connections (not shown), such as production, hydraulic, and/or electrical, or gaskets, between the equipment package **40** and the subsea equipment **10** (FIG. **1**).

In addition to fine alignment, fine alignment funnel **56** may also facilitate soft landing of the equipment package **40**. Trapped sea water in the fine alignment funnel **56** can provide a cushion or resistance for the equipment package being installed by wireline. Trapped sea water can be released via an orifice **58** at the closed top of funnel **56** that allows the trapped water to bleed out to the sea. Outer diameter of orifice **58** is smaller than bore diameter of fine alignment funnel **56**. As the water is bled out from the fine alignment funnel **56**, the equipment package **40** slowly lands on the landing platform **12** of the subsea equipment **10**. Thus, soft landing of the equipment package **40** is achieved. As explained previously, soft landing feature may be used on various types of subsea equipment, including but not limited to manifolds, PLEMs, and PLETs. Further, the soft landing wireline system could also be used in the installation of valves, actuators, chokes, and other components. It is understood by one of ordinary skill in the art that installation of the alignment members and alignment funnels could be reversed such that the alignment members are part of the equipment package **40** to be landed and the alignment funnels are part of subsea equipment lauding platform **12**. The soft landing feature of the fine alignment funnel **56** is explained further below.

In landing operation, illustrated in FIGS. **3-4**, the equipment package **40** may be lowered to the subsea equipment **10** via wireline (not shown). Once coarse alignment ring **54** engages top end **18** of the coarse alignment members **14**, the equipment package **40** continues to be lowered towards the landing base **12** of the subsea equipment **10**. The interaction between the subsea equipment-mounted coarse alignment members **14** and the coarse alignment rings **54** prevents rotation of the equipment package **40**. When equipment package **40** is lowered sufficiently, fine alignment funnels **56** engage a top end **24** of the fine alignment member **20**, as shown in FIG. **3**. Referring to FIG. **3**A, a lower perspective illustration provides more clarity of the initial engagement of the fine alignment funnel **56** with the fine alignment member **20**. A length L and an inner diameter of the fine alignment funnel **56** defines a chamber **70** within the fine alignment funnel. Sea water may be trapped in the chamber **70** of the fine alignment funnel **56** when the fine alignment member **20** enters a lower opening in the funnel. A sealing element **72** installed within the lower opening of the funnel facilitates the trapping of sea water within chamber **70**.

Once the fine alignment member **20** engages the fine alignment funnel **56**, the fluid connection **52** on the equipment package **40**, any auxiliary connections (not shown), and gaskets (not shown) disposed on the fluid connection, are aligned to mate with hub **26** on the subsea equipment **10** and corresponding connections (not shown). Sea water trapped in chamber **70** may then be bled out to the sea at a desired rate from chamber **70** via orifice **58** to soft land the equipment package **40** onto the landing base **12** of subsea equipment **10**, as shown in FIG. **4**. Fine alignment member **20** together with fine alignment funnel **56**, create a type of piston and cylinder arrangement with the trapped water in the chamber **70** acting as a cushion for the equipment package **40**. Alignment funnels and members may vary in size depending on the weight of the equipment package and rate of descent. Larger equipment would require a larger cushion of sea water and thus a larger funnel. Soft landing of the equipment package **40** advantageously reduces the potential for damage during mating, to the hub **26**, auxiliary connections such as electrical or hydraulic connections, or gaskets. Further, during removal of equipment package **40** from the landing base **12**, the chamber **70** may self-charge with sea water to allow for any subsequent soft landings.

In another embodiment illustrated in FIG. **5**, orifice **58** may be connected to a line **74** and connected to a valve **76**. The valve **76** may be located on a panel and operated by an ROV to allow sea water trapped within chamber **70** to bleed out into the sea at a desired rate and thereby allow soft landing of the equipment package **40** onto the subsea equipment **10**.

In another embodiment illustrated in FIG. **6**, an equipment package **80** may have a frame **82** as in a previously described embodiment. However, instead of coarse alignment rings the equipment package **80** may have coarse alignment funnels **84** mounted on a base of the package. As in previously described embodiment, coarse alignment funnels **84** may be mounted diagonally across from each other and facilitate general alignment of the equipment package **80** when lowered onto the subsea equipment **10** (FIG. **1**). An orifice **86** may be located at an upper end of coarse alignment funnel **84** to allow trapped seawater within the funnel to bleed out during soft landing. As in a previous embodiment, fine alignment funnels **88** with an orifice **90** may also be mounted on the equipment package **80**. This embodiment allows a larger volume of sea water to be trapped in the funnels **84**, **88** for increased cushioning and thus softer landing, which may be utilized for heavier equipment. Alternatively, orifice **86** may be connected to connected to a line **92** and connected to a valve **94**, as shown in FIG. **7**. The valve **94** controls the bleed off rate to the sea. The valve **94** may be located on a panel and operated by an ROV to open line **92** to allow sea water trapped within coarse alignment funnel **84** to bleed out into the sea at a desired rate and thereby allow soft landing of the equipment package **80** onto the subsea equipment **10** (FIG. **1**).

The invention is advantageous because it eliminates the cost of a soft landing running tool. Instead, the soft landing features are integrated onto a subsea equipment or system, and equipment package.

This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. These embodiments are not intended to limit the scope of the invention. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal language of the claims.

What is claimed is:

1. A subsea well system, comprising:

a subsea equipment lower assembly;

a subsea equipment upper assembly that lands on the lower assembly;

a first alignment post carried by one of the assemblies, the first alignment post being offset from and parallel to an axis of the lower assembly;

a first alignment sleeve carried by the other of the assemblies, the first alignment sleeve being offset from and parallel to the axis and in vertical alignment with the first alignment post while the upper assembly is landing on the lower assembly;

the first alignment sleeve having an open end that admits sea water into an interior of the first alignment sleeve, the open end being dimensioned to receive the first alignment post while the upper assembly is landing on the lower assembly;

the first alignment sleeve having a restrictive end opposite the open end, the first alignment post having a tip that is axially spaced from the restrictive end and fully within the interior of the first alignment sleeve when the upper assembly is in a fully landed position on the lower assembly; and

an orifice in the first alignment sleeve that expels sea water displaced from the interior of the first alignment sleeve as the first alignment post moves within the first alignment sleeve to the fully landed position.

2. The system according to claim **1**, wherein:

the orifice has a flow area smaller than a cross sectional area of the first alignment sleeve.

3. The system according to claim **1**, wherein:

the orifice is located at the restrictive end and has a smaller flow area than a flow area of the interior of the sleeve measured at the restrictive end.

4. The system according to claim **1**, wherein:

the restrictive end comprises a cover plate extending across the sleeve;

the orifice is located at the restrictive end; and

the orifice has a smaller flow area than a cross sectional area of the cover plate.

5. The system according to claim **1**, wherein:

the restrictive end comprises a cover plate extending across the sleeve; and

the orifice extends through the cover plate.

6. The system according to claim **1**, wherein:

the first alignment post has a base portion that is located within the alignment sleeve while in the fully landed position; and

the base portion has an outer diameter that is substantially the same as an inner diameter of the first alignment sleeve.

7. The system according to claim **1**, wherein:

the first alignment post is mounted to the lower assembly and points upward; and

the first alignment sleeve is mounted to the upper assembly, the open end of the first alignment sleeve being at a lower end of the sleeve, and the restrictive end being at an upper end of the first alignment sleeve.

8. The system according to claim **1**, wherein the first alignment sleeve has a length greater than the first alignment post.

9. The system according to claim 1, further comprising:
a second alignment post carried by said one of the assemblies, the second alignment post being parallel to the axis and located on an opposite side of the axis from the first alignment post;
a second alignment sleeve carried by said other of the assemblies, the second alignment sleeve being offset from and parallel to the axis and positioned in vertical alignment with the second alignment post while the upper assembly is landing on the lower assembly;
the second alignment sleeve having an open end that admits sea water into an interior of the second alignment sleeve, the open end of the second alignment sleeve being dimensioned to receive the second alignment post while the upper assembly is landing on the lower assembly;
the second alignment sleeve having a restrictive end opposite the open end of the second alignment sleeve, the second alignment post having a tip that is axially spaced from the restrictive end and fully within the interior of the second alignment sleeve when the upper assembly is in the fully landed position on the lower assembly; and
an orifice in the second alignment sleeve that expels sea water displaced from the interior of the second alignment sleeve as the second alignment post moves within the second alignment sleeve to the fully landed position.

10. A subsea well system, comprising:
a subsea equipment lower assembly;
a subsea equipment upper assembly that lands on the subsea equipment;
a hub on the lower assembly for mating with a corresponding connection on the upper assembly to establish fluid communication between the upper assembly and the lower assembly, the hub having a longitudinal axis;
first and second fine alignment posts carried by one of the assemblies, the first and second fine alignment posts being parallel to and on opposite sides of the axis;
first and second fine alignment sleeves carried by the other of the assemblies, the first and second fine alignment sleeves being in vertical alignment with the first and second fine alignment posts, respectively, while the upper assembly is landing on the lower assembly;
the first and second fine alignment sleeves having open ends that admit sea water into interiors of the first and second fine alignment sleeves, the open ends being dimensioned to receive the first and second fine alignment posts, respectively, while the upper assembly is landing on the lower assembly;
the first and second fine alignment sleeves having restrictive ends opposite the open ends; and
orifices at the restrictive ends of the first and second fine alignment sleeves that expel sea water displaced from the interiors of the first and second fine alignment sleeves as the first and second fine alignment posts move into the first and second fine alignment sleeves to the fully landed position, the orifices having smaller flow areas than cross sectional areas of the interiors of the first and second fine alignment sleeves to slow a speed of the landing of the upper assembly on the lower assembly.

11. The system according to claim 10, further comprising:
first and second coarse alignment posts extending from said one of the assemblies parallel to and on opposite sides of the axis, the first and second coarse alignment posts being offset from the first and second fine alignment posts;
first and second coarse alignment sleeves extending from said other of the assemblies parallel to and on opposite sides of the axis, the first and second coarse alignment sleeves being aligned vertically with the first and second coarse alignment posts, respectively, while the upper assembly is landing on the lower assembly; and wherein:
the first and second coarse alignment posts and the first and second coarse alignment sleeves are positioned such that the first and second coarse alignment posts enter the first and second coarse alignment sleeves, respectively, prior to the first and second fine alignment posts entering the first and second fine alignment sleeves, respectively.

12. The system according to claim 10, wherein:
the first and second fine alignment posts have tips located fully within the first and second fine alignment sleeves, respectively, when the upper assembly is in the fully landed position on the lower assembly.

13. The system according to claim 10, wherein the orifices are formed in the restrictive ends.

14. The system according to claim 10, wherein:
the restrictive ends comprise cover plates extending across the first and second fine alignment sleeves; and
the orifices are located in the cover plates.

15. The system according to claim 10, wherein:
the first and second fine alignment posts each have base portions that are located within the first and second fine alignment sleeves, respectively, while in the fully landed position; and
the base portions have outer diameters that are substantially the same as inner diameters of the first and second fine alignment sleeves.

16. The system according to claim 10, wherein the first and second fine alignment sleeves have lengths greater than the first and second fine alignment posts.

17. A method for landing a subsea equipment upper assembly on a subsea equipment upper assembly, comprising:
mounting an alignment post on one of the assemblies, the alignment post being offset from and parallel to an axis of said one of the assemblies;
providing an alignment sleeve with an open end, a restrictive end, and an orifice, and mounting the alignment sleeve on the other of the assemblies;
landing the lower assembly at a desired subsea location, lowering the upper assembly into the sea, and flowing sea water through the open end of the alignment sleeve into an interior of the alignment sleeve; then
lowering the upper assembly onto the lower assembly with the alignment post and alignment sleeve in vertical alignment with each other, and stabbing the alignment post into the open end of the alignment sleeve; and
continuing to lower the upper assembly onto the lower assembly, causing the alignment post to move farther into the alignment sleeve and expelling displaced sea water from the interior of the alignment sleeve through the orifice until reaching a fully landed position with a tip of the alignment post axially spaced from the restrictive end and fully within the interior of the alignment sleeve.

18. The method according to claim 17, wherein:
providing the alignment sleeve with the orifice comprises placing the orifice at the restrictive end of the alignment sleeve.

19. The method according to claim 17, wherein:
providing the alignment sleeve with the restrictive end comprises providing a cover plate across the alignment sleeve; and
providing the alignment sleeve with the orifice comprises forming the orifice in the cover plate.

20. The method according to claim **17**, wherein: providing the alignment sleeve with the orifice comprises providing the orifice with a smaller flow area smaller than a cross sectional area of the alignment sleeve.

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